IoT Passive Monitoring for Assisted Living Homes

Project Plan

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HiIPPA: Health Insurance Portability and Accountability Act of 1996

1 Introductory Material

1.1 Acknowledgement

If a client, an organization, or an individual has contributed or will contribute significant assistance in the form of technical advice, equipment, financial aid, etc, an acknowledgement of this contribution shall be included in a separate section of the project plan.

1.2 Problem Statement

The families of elderly people can often have a hard time keeping track of their elderly family members health, in order to get them the care they need. Elderly people want their family to think that they are doing ok, which leads to them misleading their family when they are not ok. If they are not doing well and need to get help it is imperative that the family is able to get them that help in a timely manner.

We are proposing a new product to designed to solve this problem. Essentially we want to use passive, non-invasive sensors to collect and store data about the elderly persons habits. In order to help the family know if their elderly relative is doing well we will collect data about eating/drinking habits, sleeping habits, and personal hygiene. This data will be analyzed to see if the elderly relative is staying within normal ranges, and the family will be notified if for example, the elderly relative stops eating. With the family notified of developments like this, they can get their elderly relative timely help for health issues.

1.3 Operating Environment

The end product that we are working on will be used indoors and will not be exposed to any extreme temperatures. Our sensors will be placed in assisted living homes so they will need to be able to withstand the normal wear and tear of similar objects in homes..

1.4 Intended Users and Intended Uses

The end users will consist of an elderly person being non-invasively monitored, and a caring relative of theirs being notified of any problems. The sensors will not be interacted with- as they are passive monitoring sensors. Relatives of those living in the homes or ?caretakers? will be the intended users of the interface we create. These users will monitor trends from the tenant’s data and be alerted of any irregularities that may warn of an underlying health issue.

1.5 Assumptions and Limitations

One assumption we've made is that there will be wifi in the home. Raspberry pi's have bluetooth but we assume the living space would be large enough that this would not be an option. Additionally, we assume this product would not be used outside the United States so medical considerations for other countries have not been taken into account, nor has the difference in building materials and styles or methods.
Tentative assumption: the sensors will be installed in an environment with only 1 subject.

Limitations:

- Non-wearable sensors.
- Passive sensors.

1.6 Expected End Product and Other Deliverables

The end product will consist of three parts: the server, data collection, and an application. These will be delivered by April 1st 2018 to our client.

The server will used to store and possibly analyze any collected data sent from other node servers.

The Data collection portion of this project will be a bit trickier. We will have to create a simulated environment to collect data or find someone willing to have sensors installed that will log when they eat or drink, use the bathroom, take a shower/bath, and sleep.

The application will simply be a way to see the historical data graphically. In future iterations of this project, it may be possible to view average statistics for all users, in addition to some trend analysis for individual users.

2 Proposed Approach and Statement of Work

2.1 Objective of the Task

The final product will include several sensors placed strategically around a house to collect data on the health habits of the person living there. These sensors will send data to a local server, which will act as middleware to a cloud server. There the data will be analyzed for trends. When an outlier is detected (signifying a health concern) a notification will be sent to the mobile app to alert relatives or caretakers.

2.2 Functional Requirements

Note: These requirements are very much in flux and are subject to change.

The project and system developed are required to

Function passively; without any active input from the subject being monitored.
Not be a wearable sensor, must be passive, non-intrusive sensors.
Collect data securely into some central location.

Tentative requirements include:

Analytics performed on the data to determine trends.
A mobile application to alert user based on certain events, as found from the data.

2.3 Constraints Considerations

Constraints

- **Security requirements-** Our project should limit access to sensitive information about individuals to those who need it. Be that a family member, member of staff, or a doctor.
- **Ease of installation-** Our project should be simple to install and add devices to so that someone who knows nothing about how it works can add monitoring to a home.
- **Testing-** There is not yet a testing environment, neither in a real-life environment, nor a simulated testing environment.
- **Cost-** we will need to consider cost when moving forward in an attempt to make the most affordable end product in addition to the expense of hosting a cloud server with as minimal traffic as possible.

- **Software Licenses-** Because this product is likely to enter the commercial market, it is necessary to be sure that we have the right to use any external software libraries we choose.

Non-Functional Requirements

- System must record an instance of someone eating/drinking
- System must record an instance of someone sleeping
- System must record bathroom activity
- App is responsive
- Data visualization
- Secure
- Report loss of sensor
- Report loss of power/low battery

Ethics

This project will not be unethical unless proper steps are not taken to ensure anonymity or that an individual's data isn't protected as that would violate the HIPAA.

2.4 Previous Work And Literature

While this project is in its infancy, the idea is not. As such, our work is not based on a previous senior design project. However, it is important to look for existing research or implementations of this idea that are already on the market. These findings will help shape our design decisions as well as help to identify potential problem areas before they arise.

There are a few existing projects that attempt to capture the goal of this one. The existing projects have all included some type of wearable sensor(*Torres, Roberto L. Shinmoto, et al.*) to monitor various aspects of a person's health or their physical state. This project is attempting to stay way from technologies of that nature but the information provided may yet prove useful.

In one case, the research and implementation into this type of elderly monitoring system was performed before the age of so-called 'smart-technology' and references being able to receive notifications via PDA device[1]. While that particular paper seems like it would be too antiquated to be of use, it is still fairly relevant. Many of its block diagrams are similar to what we've already come up with.

2.5 Technology Considerations

Because the sensors are passive it is important to preserve a degree of transparency such that the tenants in the assisted living facility don't feel that their privacy is being invaded. This leads to the decision that the sensors we select need to be smaller and thus more easily concealed.

In this project there will be a large amount of sensors sending information at any giving time. Due to the fact that there will be a vast amount of information being sent at any given time we feel that the best solution is to have a local server for each facility or home, such that information is sent to the local server and then relayed to the cloud server. The cloud server will store all of information for each individual sensor, as well as which person the sensors correlate to.

How the sensors communicate will also be an issue to address in this project. If we choose to go with wifi communication, the sensors will have both faster communication times and will communicate with the sensors more easily. Using Wifi we also have the ability to send out a pulse to ensure that a given sensor is still functional. The downside to using Wifi is that for the each facility of home there will need to be an internet connection.

Instead of using Wifi another option is to use ZigBee for communication between sensor. While this doesn't require a Wifi connection it makes it less efficient to communicate with a local server and limits the ability to check if a sensor is still functional.

Finally, the issue of which cloud service to use in the end product. Having experience in Amazon Web Services we know that setting up a cluster, which is crucial for big data analytics, can be implemented easily and works well with Java in the event we choose to use Hadoop for big data.

There is also the choice of using Google Cloud. Having no previous experience with Google Cloud there would be a learning curve and is harder to secure than Amazon Web Service, which is important due to the fact that we are sending personal information across the network.

2.6 Safety Considerations

Due to the nature of passive sensors, there are virtually no physical safety concerns in our project. However, the quantity and nature of the data collected provides some potential privacy concerns. Thus, we will need to ensure the data transmission and storage is secure.

2.7 Possible Risks And Risk Management

One possible risk would be edge cases that may prevent the sensors from collecting data that is useful. This could include inconsistencies to how tenants eat or differences in faucet usage that could lead to inconclusive data about drinking habits. Our team will have to consider all possibilities for these various use cases to ensure that the sensors we use are collecting data that is meaningful and can provide insight to a tenant's health trends.

Another risk for our project is investors having different ideas or plans regarding software or hardware than we come up with for the project. A unique aspect our our project is that it is in the early stages of development to becoming a business. That presents specific challenges when it

comes to capital that could dictate what our final product turns out to be. It was pointed out by our Client that the software solution we use could change if an investor comes onboard the project and needs to interface with a specific program. This would nullify the work that we would have put into the other solution and mean that we would need to start from scratch in some portion of the project. Our team will need to stay prepared for risks such as these and be aware of other options than our chosen solution.

2.8 Project Proposed Milestones and Evaluation Criteria

The first key milestone will be buying the sensors we decide on. For the first portion of the semester we will be researching and compiling a list of possible sensors to use for the project. After comparing different sensors with similar functionalities to each other and finding the strongest candidates, we will present a finalized list of sensors we need for the project to the client with justifications of why they are the best and why they are necessary. The client will discuss our list with us and eventually approve a finalized list of sensors to buy. Our final list will be evaluated based on our justifications for each sensor on the list, because those justifications will prove out research was thorough.

The next major milestone we will accomplish this semester is successfully storing data from the sensors on our local server. For this to happen we will need to set up an environment to test the sensors and get them working. Then we will need the sensor data sent to the server. If the sensors being triggered shows up on the server consistently then we will have been successful.

2.9 Project Tracking Procedures

Our client presented us with a tentative schedule at the beginning of the semester. In our first meeting with the client we refined the tentative schedule and have been keeping up with it since. To keep track of progress we are discussing it in our meetings and it is recorded in our meeting notes as well as weekly reports. We intend to stick with our planned schedule and falling behind that schedule in any area will result in discussion about how to catch back up.

2.10 Task Approach

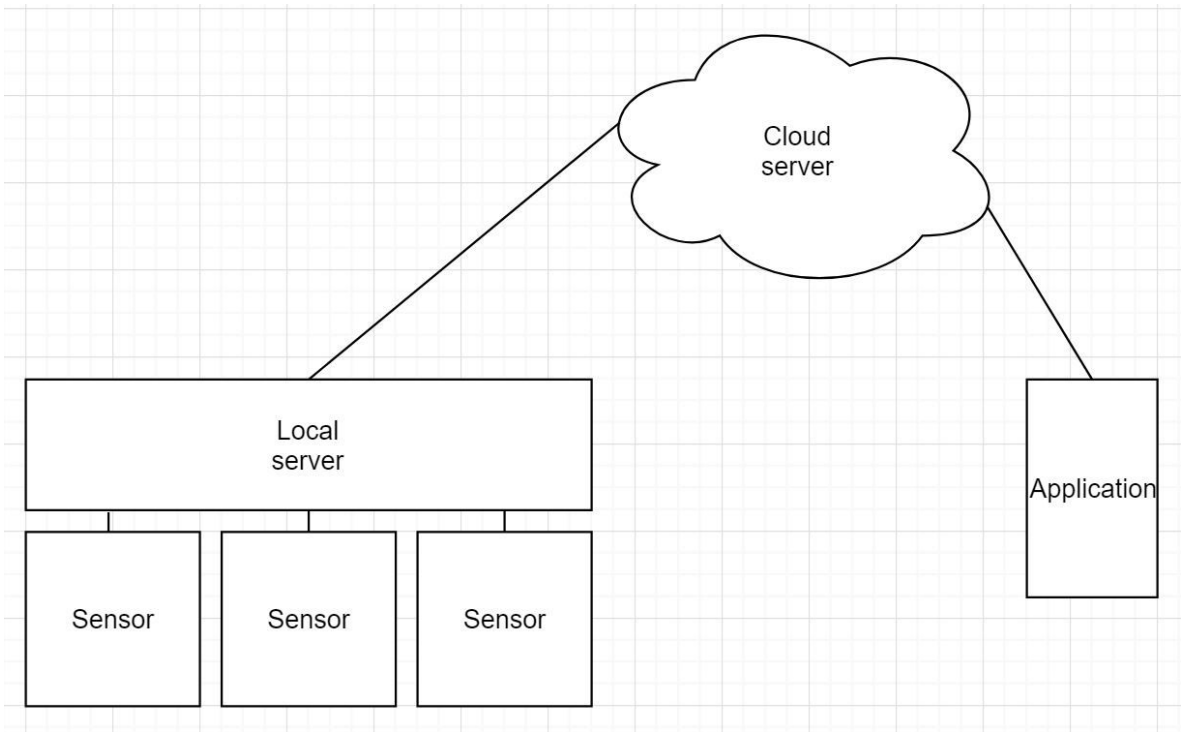

Figure 1

3 Project Timeline, Estimated Resources, and Challenges

3.1 Project Timeline

High level timeline:

January	February	March	April
-Brainstorm various sensor use cases -Determine what data will be useful to health monitoring -Generate and justify list of sensors to collect data	-Work on hardware and software flowcharts -Research cloud/ local server solutions -Brainstorm ways to bypass selected sensors -Begin work on data visualization solution	-Present and finalize sensors and use cases -Design and build tests for sensors -Implement interface between sensors and storage -Work on storage system (cloud and local)	-Refine storage solution -Begin collecting test data -Finish MVP of app prototype -Prep for in depth testing over the summer (done by Client)

Detailed timeline:
*See Section 4.3 for Gantt Chart

<u>Deliverables:</u>

1. Server
    1.1. Research into upscalable cloud platforms capable of storing and performing data analysis
    1.2. Implementation of a cloud server based on research
2. Data collection
    2.1. Research into passive, non-invasive sensors to monitor sleep, eating/drinking, and bathroom habits
    2.2. Create a simulated testing environment to demonstrate data collection functionality
    2.3. Research into and implementation of a data transmission solution
    2.4. Establish a local server to handle communication with the sensors and the cloud platform for scalability and simplicity.

2.4.1. The local server solution is a tentative plan. Further work and research may deem it necessary to use something else as a relay between the sensors and the cloud server.

3. App
   3.1. Research data visualization techniques and libraries
      3.1.1. Initially, a simple textual display of available data will be implemented.
      3.1.2. Time permitting, more research into graphical visualization of usage history will be performed. An implementation will be provided, should research prove sufficient.
   3.2. Provide a prototype implementation of data visualization based on research

3.2 Personnel Effort Requirements

Task	**Amount of Personal Effort**
Compile and Finalize List of Sensors	High
Hardware Flowchart	low
Project Plan	low
Design Document	low
Design and Implement Sensor Testing	High
Implement Data Storage System	Moderate
Implement Data Visualization	Moderate

The three tasks that will take the least amount of effort are the hardware flowchart, project plan, and design document, but this is not to understate the importance of these documents in the least. These are tasks that we have been directly or indirectly working on since the beginning of the project as we have been meeting as a team, with our client, or with our advisor. Once the content is discussed as a team we each completed each of our assigned parts of the Project plan with relative ease. The same will go for the hardware flowchart and the design document, although these we be created together as a team to an even greater degree.

Implementing a data storage system and implementing data visualization will require a moderate amount of effort. While these are serious roles for the project they will take a smaller amount of effort than other tasks because there are pre-existing systems for both areas that we can learn from and model our designs after.

Finally, compiling and finalizing sensor list and designing and implementing useful sensor tests will most likely be our greatest challenges. The reason for this is because these are new areas that we will be able to find little to no information for our specific project. We may have to go through several rounds of debate and reasoning to come up with the best solutions that we are able to implement for these tasks.

3.3 Other Resource Requirements

There are several things that we will need to acquire to implement our project and the first are the sensors. This is the heart of our project and because of that it is the first thing on our agenda. This sensor list will be scrutinized over and over again that the sensors being bought are in fact the best sensors that we will be able to afford for our application.

Another important resource we will need is a raspberry pi. As it stands now the raspberry pi will be our device that will have our data from the sensors funneled into. This will be our point in between the sensors and our storage device.

Lastly, we will need to have testing environments for our sensors. There will be two different directions that testing can go. 1.) We attached sensors to existing infrastructure that would be identical or similar enough to our use cases that we could accurately test the sensors. 2.) We create our own test environment for our sensors(e.g. Have water flow through a pipe that a flow meter could then measure).

3.4 Financial Requirements

Resource	**Cost**
Sensors	Unknown
Cloud server subscription	Unknown
Building materials for simulation environment	Unknown

4 Closure Materials

4.1 Conclusion

The elderly currently have two options, get a live-in nurse, or move to a nursing home to live out the rest of their days. Our plan is to create an internet of things that will allow for remote monitoring of their health. This will create peace of mind for family members as well as be able to provide some insight to a doctor should one be necessary. Our solution will consist of sensors sending data to a local server. This server will perform any formatting or interpretation of the data and will then send the data to the cloud server for analysis. The cloud server will have to handle requests for that information and will have to send it in such a way that the application will be able to display it textually or graphically. By implementing this solution to the growing problem of people getting old, we hope to improve the quality of life and happiness of our elderly loved ones as they move from this life to the next.

4.2 References

Context-Aware Wireless Sensor Networks for Assisted Living and Residential Monitoring - IEEE Journals & Magazine, ieeexplore.ieee.org/document/4579768/?reload=true.

Torres, Roberto L. Shinmoto, et al. “A Battery-Less and Wireless Wearable Sensor System for Identifying Bed and Chair Exits in a Pilot Trial in Hospitalized Older People.” *PLOS ONE*, Public Library of Science, journals.plos.org/plosone/article?id=10.1371/journal.pone.0185670.

4.3 Appendices

Gantt Chart